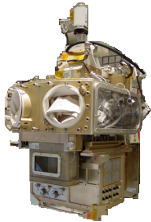


# LMM



## Light Microscopy Module (LMM)

The LMM is a microscopic fluids research instrument featuring an imaging light microscope with laser diagnostics. Imaging techniques of high resolution color video microscopy, bright field, dark field, phase contrast, differential interference contrast, fluorescence and confocal microscopy are combined in a single LMM configuration with dynamic and static light scattering techniques to allow a very broad characterization of fluids, colloids and two-phase media.

*PI-specific and multi-user hardware customizes the FIR in a unique laboratory configuration to perform fluids research effectively.*



## FCF Fluids Integrated Rack

- Power Supply
- Avionics/Control
- Common Illumination
- PI Integration Optics Bench
- Imaging and Frame Capture
- Diagnostics
- Environmental Control
- Data Processing/Storage
- Light Containment

**CVB**

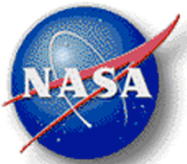


## PI Specific Hardware (Fluids, Biological or other discipline)

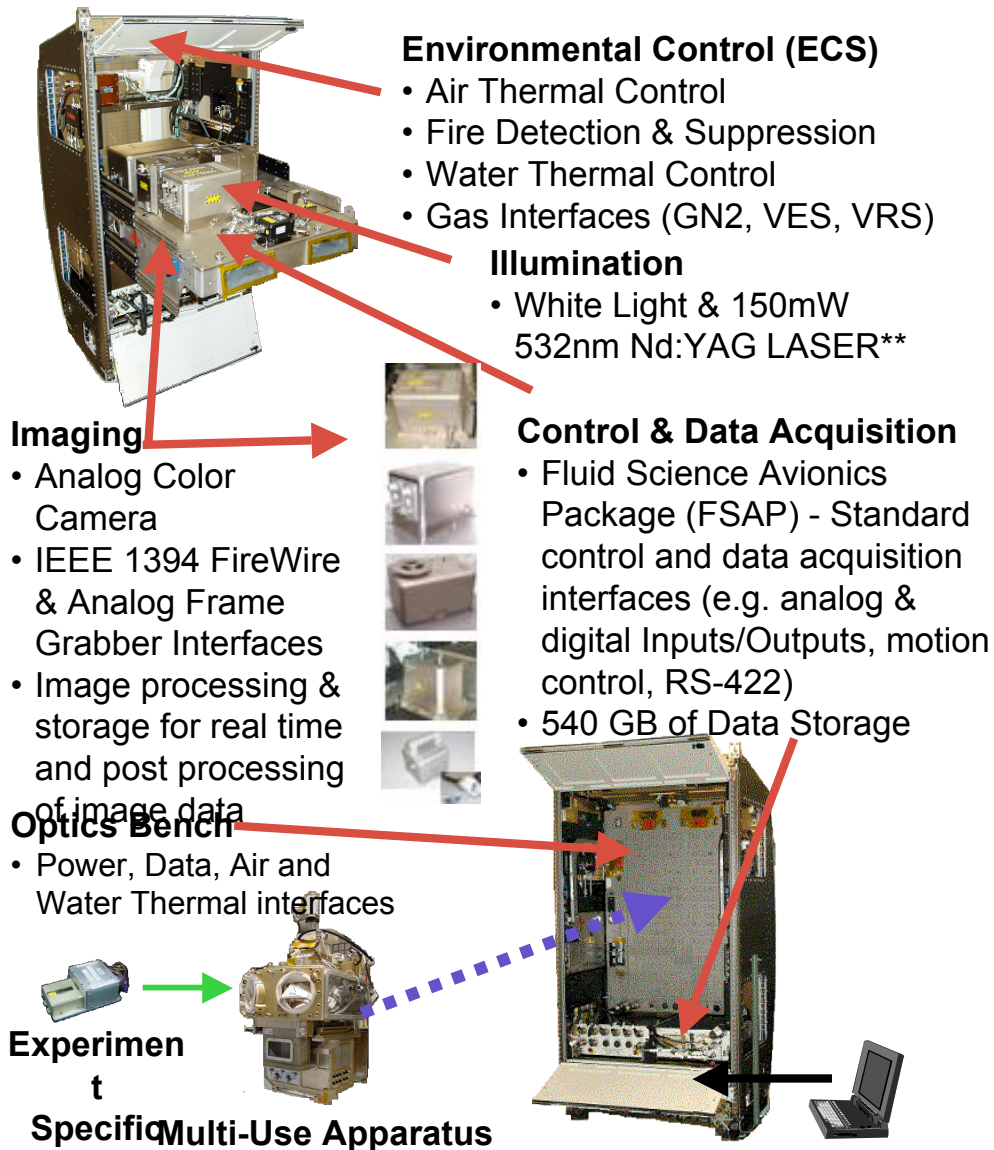
- PI Sample Cell with universal Sample Tray
- Specific Diagnostics
- Specific Imaging
- Fluid Containment

## Multi-Use Payload Apparatus

- Test Specific Module
- Infrastructure that uniquely meets the needs of PI experiments
- Unique Diagnostics
- Specialized Imaging
- Fluid Containment



# Fluids Integrated Rack (FIR) Overview



## Discipline:

- Fluid physics, Biology, Biomedical

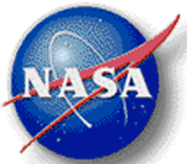
## Science Target:

- Study fluids, physical, and biological phenomena in the absence of gravity

## Main Features:

- Optics Bench (OB): Platform for mounting experiment. 13.3" x 35.2" x 19.5" on front of OB.
- White light package
- Nd:YAG laser: 532nm, 150mW. Provides laser source for diagnostic techniques such as Particle Image Velocimetry\*\*
- Color Camera Package: 24 Bit, 3 chip CCD\*\*
- Mass: max. 600 lbs
- Power: Nominal 672 W/1600W max @ 28Vdc
- Thermal Cooling: 3 kW water (MTL); 1300 W air (provided at 20-30 deg C)

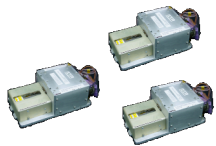
\*\*Note: Not on first flight



# Light Microscopy Module (LMM) Integrated with FIR

## Core Leica Microscope

- Script driven, on-orbit microscope facility, that coupled with FIR capabilities provides optical diagnostics for PI experiments.
- LMM can be run from the ground, as well as on-orbit if needed

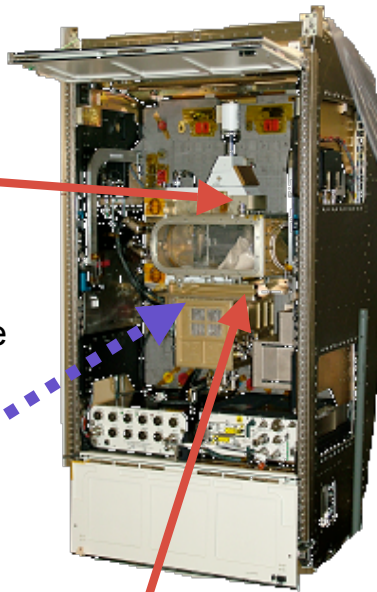


## Science Specific Hardware

- PI Sample Cell with universal Sample Tray

## Automated Science

- Extensive crew training is minimized due to the level of LMM motorization and automation when combined with software scripting capabilities



## Auxiliary Fluids Container

- The AFC provides one level of containment. Two sealed glove ports, elect pass through. 1/4" thick Lexan® windows with Viton seals

## Discipline:

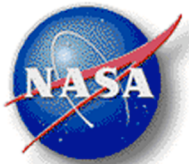
- Biology, Biomedical

## Science Target:

- Study biological, physiological, and biomedical phenomena in the absence of gravity
- 1st Experiment: Constrained Vapor Bubble (CVB) Experiment

## Main Features:

- Laboratory grade high resolution digital cameras (8-bit and 12-bit)
- Auxiliary Fluids Container: 1 level of containment; working volume = 1.9 ft<sup>3</sup> ~ 1 MLE
- Can perform colormetric measurements
- LMM is scripted to run and can be adjusted to comply with specific measurement protocols
- Confocal fluorescence microscopy with a 532 nm and a 488 laser (differed capability)
- Wide-field fluorescence microscopy
- White Light Microscope
- Thin-film interferometry
- Imaging modalities: Bright field, Dark field, Differential Interference Contrast (DIC), Phase Contrast
- Objectives: 0.5x (Bertrand Lens), 10x, 20x, 40x, 50x (LWD), 63x (oil), & 100x (oil)



## FIR with Integrated LMM General Capability

- NASA rack, scheduled to fly on 17A.
- Multi-research research capability designed to study fluids, physical, and biological phenomena in the absence of gravity
- Diagnostic capabilities of the FIR include:
  - Illumination
    - White light package
    - 532 nm Nd:Yag Laser
    - Color camera, CIR camera and Illumination compatibility
- Diagnostic capabilities of the LMM include:
  - Confocal fluorescence microscopy to provide enhanced 2- and 3-dimensional visualization of fluorescent samples excited at 532 nm and 488 nm laser
  - Wide-field fluorescence microscopy
  - White Light Microscope
  - Thin-film interferometry
  - Laboratory grade high resolution digital cameras (8-bit and 12-bit)
  - Imaging modalities: Bright field, Dark field, Differential Interference Contrast (DIC), Phase Contrast
  - LMM will house several different objectives with magnification of
    - 0.5x (Bertrand Lens), 10x, 20x, 40x, 50x (LWD), 63x (oil), & 100x (oil)



## FIR with Integrated LMM General Capability

- The FIR with the integrated subrack facility, Light Microscopy Module (LMM), will provide the following in-situ analysis capabilities:
  - Immunocytochemistry/Immunohistochemistry
    - Fluorescent Microscope
  - Proteomic analysis for genetics
    - Fluorescent Microscope
  - Rapid Identification of ISS Contaminants
    - White Light Microscope
  - Medical Diagnostics
    - White Light Microscope
  - Microorganism Identification
    - White Light Microscope/Fluorescent Microscope
- The basic scenario for all LMM experiment operations is telescience
  - The facility and experiment shall be commanded via automated procedures or direct commands sent from the ground
- The LMM is remotely controllable with or without skilled crewmembers



This diagram illustrates the assembly of a microscope. The central component is the microscope body, which includes a base, a column, and a stage. Various accessories are shown in an exploded view around the main unit, with red dashed lines indicating their assembly points. These accessories include: a binocular eyepiece at the top; a stage with a slide and a cover slip; a light source (green box) connected to a power cord; a filter (blue grid) positioned between the light source and the stage; a condenser (yellow box) located below the stage; a base (red box) for the entire unit; and a carrying case (green box) for storage. The diagram is presented in a 3D perspective view.



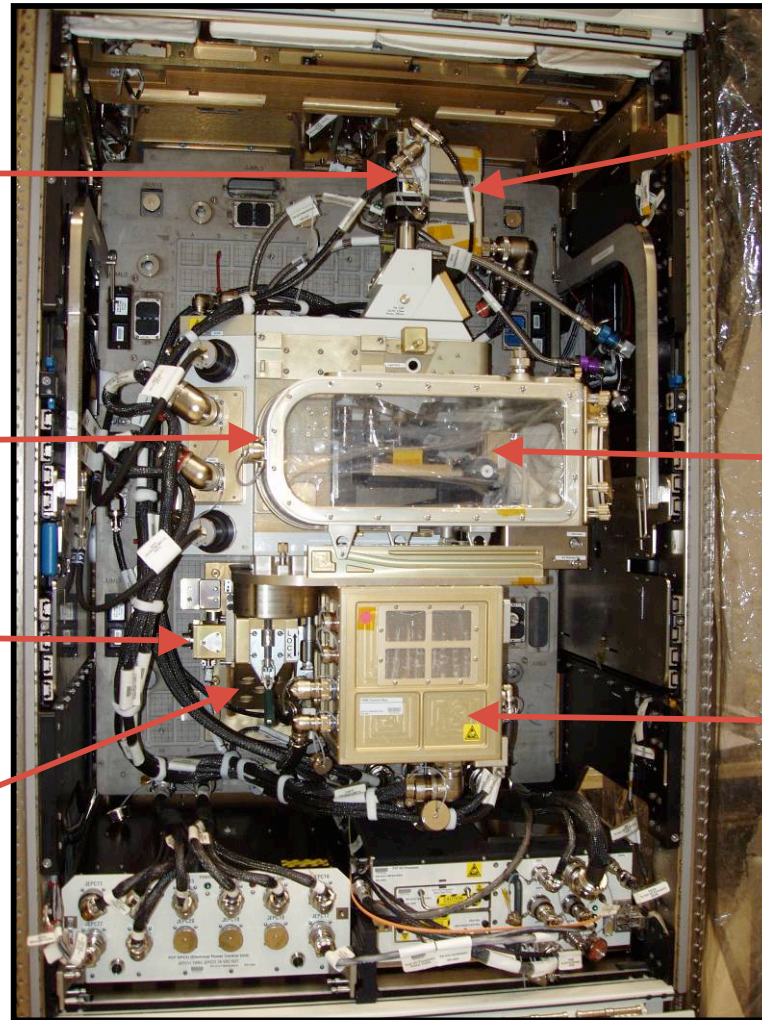
## Light Microscopy Module / Constrained Vapor Bubble

QImaging  
Camera

Microscope

SAMS TSH

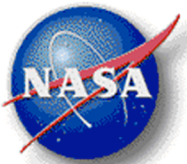
Spindle  
Bracket



CVB Control Box

Auxiliary Fluids  
Container

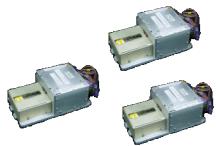
LMM Control Box



# FIR with Integrated Light Microscopy Module (LMM)

## Core Leica Microscope

- Script driven, on-orbit microscope facility, that coupled with FIR capabilities provides optical diagnostics for PI experiments.
- LMM can be run from the ground, as well as on-orbit if needed

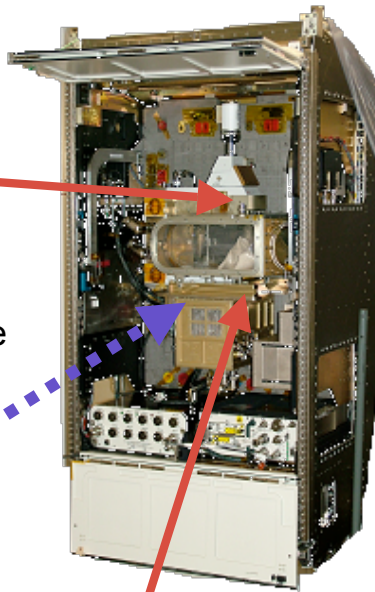


## Science Specific Hardware

- PI Sample Cell with universal Sample Tray

## Automated Science

- Extensive crew training is minimized due to the level of LMM motorization and automation when combined with software scripting capabilities



## Auxiliary Fluids Container

- The AFC provides one level of containment. Two sealed glove ports, elect pass through. 1/4" thick Lexan® windows with Viton seals

## Discipline:

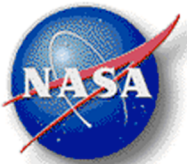
- Biology, Biomedical

## Science Target:

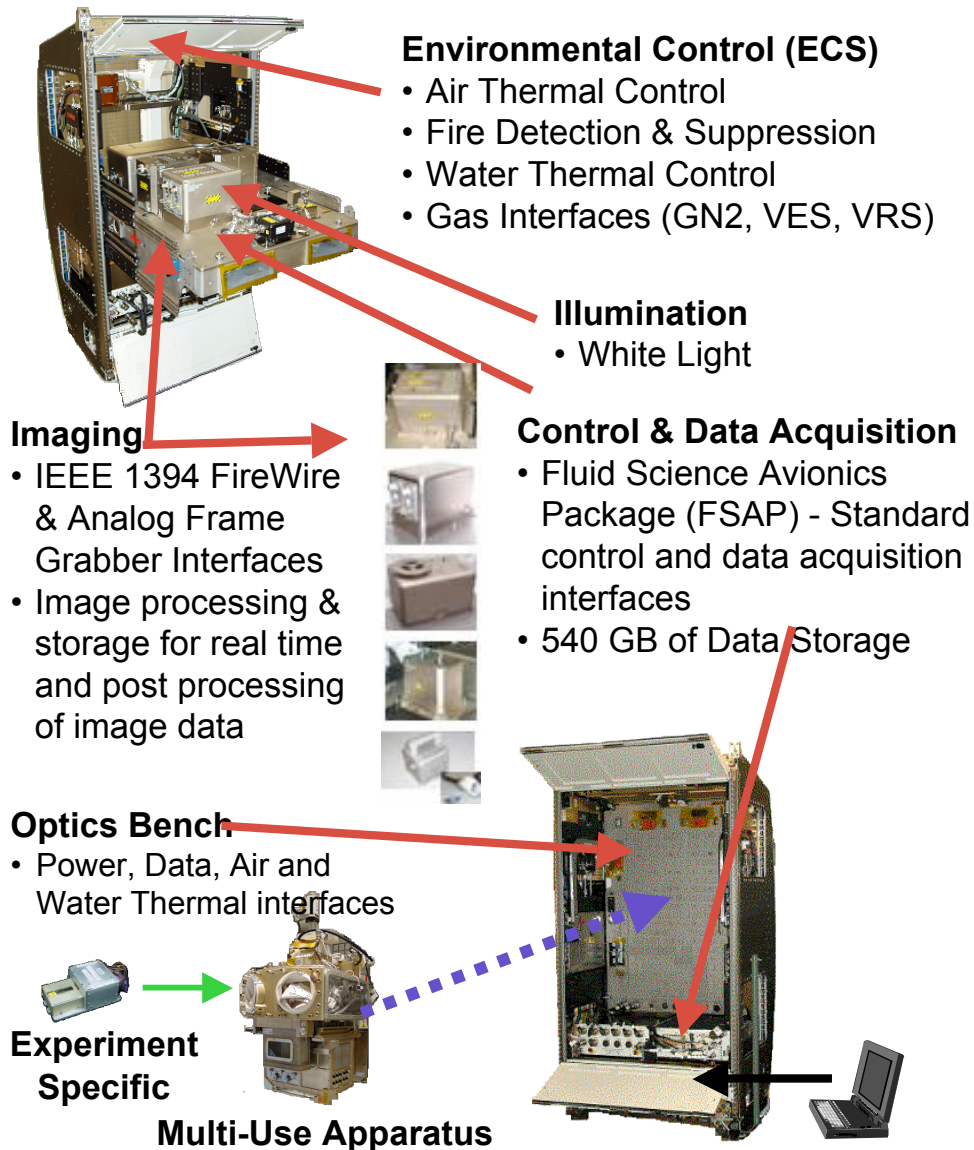
- Study biological, physiological, and biomedical phenomena in the absence of gravity
- 1st Experiment: Constrained Vapor Bubble (CVB) Experiment

## Main Features:

- Laboratory grade high resolution digital cameras (8-bit and 12-bit)
- Auxiliary Fluids Container: 1 level of containment; working volume = 1.9 ft<sup>3</sup> ~ 1 MLE
- Can perform colormetric measurements
- LMM is scripted to run and can be adjusted to comply with specific measurement protocols
- White Light Microscope
- Thin-film interferometry
- Imaging modalities: Bright field
  - *Dark field, Differential Interference Contrast (DIC) and Phase Contrast upgradeable*
- Objectives: 0.5x (Bertrand Lens), 10x, 20x, 40x, 50x (LWD), 63x (oil), & 100x (oil)
  - *20x, 40x, 63x (oil), & 100x (oil) not required for CVB*
- Upgradeable for biological applications:
  - *Confocal fluorescence microscopy capable with a 532 nm and a 488 laser upgradeable*
  - *Wide-field fluorescence microscopy upgradeable*



# Integrated FIR/LMM Payload



## **Discipline:**

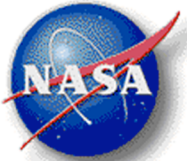
- Fluid physics, Biology, Biomedical

## **Science Target:**

- Study fluids, physical, and biological phenomena in the absence of gravity

## **Main Features:**

- Optics Bench (OB): Platform for mounting experiment. 13.3" x 35.2" x 19.5" on front of OB.
- FSAP -. analog & digital Inputs/Outputs, motion control, RS-422
- White light package
- Mass: max. 600 lbs
- Power: Nominal 672 W/1600W max @ 28Vdc
- Thermal Cooling: 3 kW water (MTL); 1300 W air (provided at 20-30 deg C)



## FIR Interfaces Used By LMM/CVB

- ***Mechanical Interfaces:***

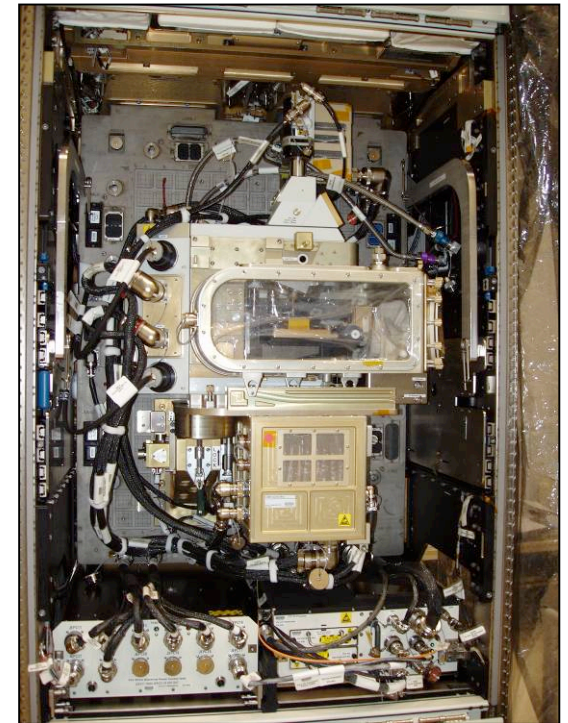
- LMM utilizes the Threaded Mounting Holes on the FIR Optics Bench to mount the microscope.
  - The T-Slots on the FIR Optics Bench are used as guides to properly place the LMM Hardware.
- The CVB Control Box is mounted to Universal Mounting Location (UML) #4.

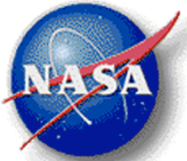
- ***Thermal Interfaces:***

- LMM utilizes ISS MTL cooling water at the FIR Water Interface Panel.
- LMM utilizes Air Cooling at UML #4.
- LMM utilizes ATCU Air Cooling for the rest of their hardware on the FIR Optics Bench.

- ***Diagnostics:***

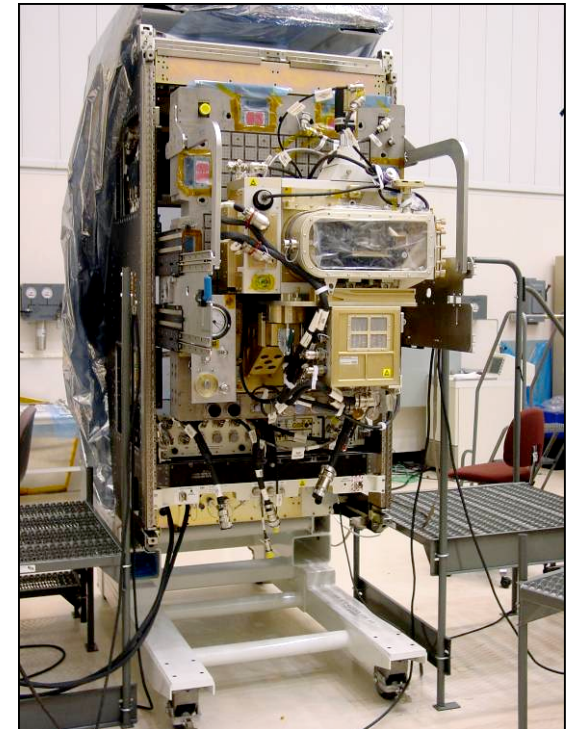
- FIR White Light
  - LMM designed their own light pipe to interface with the FIR White Light.
- Space Acceleration Measurement System Triaxial Sensor Head (SAMS TSH)
  - The SAMS TSH mounts to the LMM Spindle Bracket.





## FIR Interfaces Used By LMM/CVB

- Electrical Interfaces:
  - LMM utilizes 28 VDC power at the UML and the PI Test Section Power Connector.
  - LMM utilizes CAN Bus at the Generic Package Interface (GPI) #1.
  - LMM utilizes FireWire at the GPI #1.
  - LMM utilizes Ethernet at the PI Test Section Data/Control Connectors.
  - LMM utilizes Digital I/O at the PI Test Section Data/Control Connectors.
  - LMM utilizes A/D and D/A conversion at the PI Test Section Data/Control Connectors.

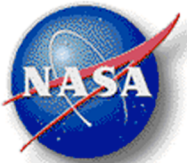




## FIR Interfaces Used By LMM/CVB

- Software Interfaces:
  - FIR Avionics Package
  - Image Storage and Processing Unit – Analog (IPSU-A)
  - FCF I/O Processor
    - LMM will save science data to the FCF I/O Processor hard drives.
  - TReK
- ISS Hardware:
  - ISS Portable Vacuum Cleaner
    - LMM will use this vacuum to clean up debris should a sample break under the microscope. (Off nominal situation)





# LMM Thermal System

Glenn Research Center

- Systems cooled by air from the FIR ATCU
  - Microscope
  - QImaging Camera
- Systems cooled by forced air flow
  - LMM control box (fan)
  - CVB control box (UML port)
- Water cooling
  - AFC internal volume
  - CVB module

